INDIVIDUAL DIFFERENCES IN WORKING MEMORY CAPACITY AND L2 READING COMPREHENSION

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Abstract: This review briefly attempts to establish a relationship between individual differences in working memory (WM) capacity and reading comprehension. First, it discusses some findings on such relationship concerning individuals' first language (L1), and second, it shows evidence for such relationship in a second language (L2). Finally, the review findings have shown that individual differences play a crucial role in the way individuals use their knowledge to organize the flow of information processing in the L2 reading comprehension process.

Resumo: Esta resenha tenta, brevemente, estabelecer uma relação entre as diferenças individuais em relação à capacidade de memória de trabalho e compreensão de leitura. Primeiramente, a resenha discute resultados de estudos realizados sobre tal relação, levando em consideração a primeira língua ou língua materna (L1). Em seguida, revela evidências para tal relação na língua estrangeira ou segunda língua (L2). Por fim, esta revisão teórica demonstra que as diferenças individuais têm um papel crucial na forma como os indivíduos usam o seu conhecimento para organizar o processamento de informações durante o processo de compreensão de leitura na L2.

Keywords: individual differences, working memory capacity, reading comprehension, information processing, first and second language.

Palavras-chave: diferenças individuais, capacidade de memória de trabalho, compreensão de leitura, processamento de informação, primeira e segunda língua.

1 Introduction

Recently, a great community of researchers has been showing interest in carrying out research on the topic of individual differences among humans within the Cognitive Psychology and Second Language

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Acquisition (SLA) fields.

Although individual differences are present in L1 development, such differences can be overwhelmed by the huge range of individual differences evident in second language (L2) development, in which most learners fail while dealing with the target language. (TL) (HARRINGTON, 1992; MIYAKE; FRIEDMAN, 1998; SHAH; MIYAKE, 1999).

According to some authors, for example Miyake and Friedman (1998), some learners easily achieve a high level of L2 proficiency, while others have difficulty in mastering some cognitive tasks, such as reading, listening, writing, and/or speaking, even if they have the same amount of exposure to input of L2 linguistic aspects.

Departing from these facts, there is a common consensus in the literature that either the success or failure in the L2 is the result of an aggregation of variables in input. Such variables are responsible for the L2 development and proficiency improvement and they can be supported by cognitive constructs such as working memory (WM) capacity, for example.

Thus, this brief review attempts to establish a relationship between individual differences in WM capacity and L2 reading comprehension by suggesting that WM capacity may act in aiding or limiting text organization and reading comprehension.

2 Review of the literature

Although a plethora of definitions can be found in the literature on the terms of *working memory* and *working memory capacity*, I have decided to adopt Miyake and Friedman's (1998) comprehensive conception of working memory. These researchers claim that working

memory is “a computational arena or workplace, fueled by flexibly deployable, limited cognitive resources (or activation) that support both the execution of various symbolic computations and the maintenance of intermediate products generated by these computations” (MIYAKE; FRIEDMAN, 1998, p. 341). Essential to this definition is the dynamic nature of the working memory capacity system responsible for both processing and storage of functions and the fact that it is a limited-resource system (BADDELEY, 1990, 1992a, 1992b).

As regards WM capacity, which is considered dynamic and limited in nature, I will consider the concept proposed by Harrington (1992). This researcher defines WM capacity as “the relative capacity to intake and integrate information in immediate, on-line processing” (Harrington, 1992, p. 123). These definitions of WM and WM capacity are in line with the framework of the L2 information processing models (McLAUGHLIN; ROSSMAN; McLEOD, 1983; BIALYSTOK; HAKUTA, 1994), which consider L2 learning as the development of cognitive skills, such as reading comprehension, linguistic planning and problem-solving (BADDELEY, 1986; BADDELEY; LOGIE, 1999).

Concerning humans’ information processing, it is essential to highlight that people vary according to their WM capacities, in that individuals with a larger WM capacity perform cognitively better in complex tasks (in reading comprehension, for example), both in L1 (DANEMAN; CARPENTER, 1980, 1983; TOMITCH, 1996, 2000a) and in L2 (HARRINGTON, 1992; ; SAWYER, 1992; HARRINGTON; MIYAKE; FRIEDMAN, 1998). In the eyes of some researchers (DANEMAN; CARPENTER, 1980, 1983; DANEMAN; GREEN, 1986; TOMITCH, 1996), individual differences in L1 development may reflect differences in their WM capacity, precisely between storage and

processing functions while performing complex cognitive tasks, such as reading comprehension and grammatical sensitivity (HARRINGTON; SAWYER, 1992), among others.

In the same line of thought, Carpenter, Miyake, and Just (1994) claim that WM capacity is an important determining factor of L1 proficiency. Moreover, according to these authors' findings, WM is responsible for explaining individual differences either in L1 or L2 by showing significant results that individual differences in L1 have strongly been in parallel with those from L2.

According to Harrignton's (1992) findings, individuals use WM capacity and also extra attentional resources when dealing with the L2 learning/acquisition process. In a similar fashion, important results were found in the literature showing that L2 reading comprehension demands greater extent from WM capacity than L1 reading comprehension (HARRINGTON, 1992; BERQUIST, 1998; MIYAKE; FRIEDMAN, 1998).

According to Miyake and Friedman (1998), an extra load in the system would affect the quality and speed of language development. In this sense, a larger WM capacity can be associated with faster and more efficient L2 learning, by making it easier for learners to keep all the relevant pieces of information simultaneously activated within their WM capacity (MIYAKE; FRIEDMAN, 1998).

More specifically in L1, the view of WM capacity as a source of individual differences in L1 development and use is already incontestable (JUST; CARPENTER, 1980, 1983; KINTSCH; van DIJK, 1978). A wide range of studies seems to agree that processing and storage functions differ from individual to individual being one of the crucial aspects in

determining their performance in complex cognitive tasks, such as reading comprehension and grammatical sensitivity to abstract grammatical regularities from texts. However, some findings have also been provided in the domain of L2 development, pointing to an even greater role of WM capacity in L2 than in L1 by the adult learner (ELLIS; SINCLAIR, 1996; BERQUIST, 1998; HARRINGTON, 1992; MIYAKE; FRIEDMAN, 1998).

The findings of the studies in L2 WM provide support to the view that WM capacity is indeed at play not only in L1 but also in L2 development (MIYAKE; FRIEDMAN, 1998). Harrington (1992) hypothesizes that the L2 *bottom-up*[i] cognitive processes (when one recognizes information and makes decisions) may place an extra burden on learners' attentional resources and a load on their WM capacity. These factors suggest that differences in individuals' WM capacity may provide some insight into the complex process of L2 reading comprehension and L2 text organization and mapping.

As regards individual differences in WM capacity and L2 reading comprehension, the study of Daneman and Carpenter (1980) is crucial to be discussed here. According to these researchers, individual differences in reading comprehension may reflect differences in WM capacity. In other words, readers with more efficient cognitive processes (the good readers) have additional capacity to rehearsal and maintenance, while readers with less efficient cognitive processes (the poorer readers) demand all their processing capacity in order to execute the minimal computations. Still, the researchers claim that there are two relevant aspects of reading comprehension: (1) fact retrieval[ii], that might reflect differences in processing capacity, and (2) computation of pronominal WM capacity, which is closely related to fact retrieval and linked to WM

capacity, as for example, when an author uses a pronoun in a text assuming that the referential pronoun is activated in the readers' WM.

In this respect, Daneman and Carpenter (1980, 1983) claim that good readers have a higher probability to maintain the referent noun still active, whereas poor readers require more computations to do that. Otherwise, if the referent is no longer in WM, readers have to establish a search in their long-term memory (LTM). In fact, such search or retrieval[2] is more likely to be well performed by better readers, since they might be more successful for initially storing the original referent (ENGLE, 1996).

Moreover, Daneman and Carpenter (1980) suggest that the storage functions demand information concerning semantic, syntactic and pragmatic information for computing the relationship between and within clauses and utterances (TOMITCH, 1996), while processing demands all processes involved in reading comprehension: parsing, decoding, lexical accessing, interference and integrating (DANEMAN; CARPENTER, 1980; TOMITCH, 1996). Thus, for the reader to comprehend a text, s/he needs to previously read information from the text, and also "compute the necessary relationships in the stream of input" (TOMITCH, 1996, p. 72, based on JUST; CARPENTER, 1992).

On the topic of this dual function of WM capacity, which implies storage and processing functions, the early traditional method to WM capacity and reading comprehension was the digit span test or word span (MILLER, 1956; SIMON, 1974, as cited in TOMITCH, 1996), although it cannot be considered a full reading ability measurement (DANEMAN; CARPENTER, 1980; TOMITCH, 1996), since it assess

only the storage function. However, the fullest measure of WM capacity, which measures storage and processing functions available during reading comprehension, is the test proposed by Daneman and Carpenter (1980), the *Reading Span Test (RST)*. The RST is considered to be a proper measure of WM capacity that definitely correlates with measures of reading comprehension, which includes fact retrieval and pronominal reference (TOMITCH, 1996).

Although WM capacity can be measured according to the reading comprehension ability, some studies have taken into account the relationship between WM capacity and syntax (ELLIS; SINCLAIR, 1996; SKEHAN, 1989; HARRINGTON; SAWYER, 1992). One of the complex cognitive tasks while reading an L2 text is to deal with abstraction and structure of rules, since a great amount of attention has to be attributed to the suppression of the learner's L1 rule system. According to Just and Carpenter (1992), such complex cognitive task takes place mainly when computing syntactic information from successive words, phrases and sentences in a given text.

In the same line of thought, Harrington and Sawyer's (1992) findings show that higher L2 reading spans are more successful in the *Test of English as a Foreign Language* - TOEFL proficiency test – both in the sections related to grammar and vocabulary. In line with these studies, Miyake and Friedman's (1998) findings corroborate those of Harrington and Sawyer (1992) by suggesting that there has been a strong relationship between L2 learners' grammatical knowledge and their WM capacity. Both studies proposed a model in order to verify the relationship between WM capacity and L2 syntactic comprehension, since they recognize that such relationship has an impact on L2 proficiency.

In Miyake and Friedman's (1998) study about Japanese learners of English and also English native speakers, these researchers could observe that learners' individual differences are related to their WM capacity and to their L2 cue preferences. They consider this relationship to illustrate the way learners understand complex sentences in English while reading a text in an L2, for example. The authors' conclusion proposes that L2 WM straightly interferes with both learners' L2 cue preference and syntactic comprehension.

Besides readers' understanding of sentence structure and propositions (or ideas) in L2 reading comprehension, their knowledge of the overall organization of a text might facilitate the readers to encoding and subsequent retrieval of text information (CARRELL, 1984, 1992; van DIJK; KINTSCH, 1983; TOMITCH, 1996). This view presumes that readers' perception of text organization may cause an impact on readers' text comprehension. For van Dijk and Kintsch (1983, as cited in TOMITCH, 1996), this position assumes that more proficient readers have a strategic way to process texts, are more able to use text structure and to identify important clues in the text. It seems that more proficient readers are better to remember the main ideas in the texts (TORRES, 2003).

Taking this into account, Tomitch (2000b) suggests that the more fluent the readers are, the more able they are to perceive what information is important in the text as well as to construct main ideas from the text. In addition, the most proficient readers know how to use their previous knowledge successfully in order to match it with the incoming information to form a complete macrostructure (van DIJK; KINTSCH, 1980, 1983). In this sense, their perception of text organization leads them to a larger comprehension of the text. In contrast,

less proficient readers do not have the same ability to deal with text organization, since they are less aware of it and they cannot distinguish the most important ideas from the least important ones in the text. It means that these readers consider all ideas equally important in a text, and because of that they are not able to build a hierarchical macrostructure, thus "drawing more on working memory resources for the storage and processing of textual information" (TOMITCH, 1996, p. 73).

Regarding differences among individuals, Tomitch (1996) investigated the relationship between individual differences in WM capacity, text organization perception, and reading ability in L1. Concerning the use of text structure, this researcher's results reveal that more experienced readers have a tendency to follow the author's text structure in order to systematize their recall of text information. Thus, better readers are more able to perceive the author's main ideas and details in the text. Tomitch (1996) raised the possibility that less proficient readers use their knowledge of real-life situations (problems and solutions) when dealing with problem-solution in reading. Her findings show that less proficient readers tend to fail to report distortions and include very little information from the text.

In a further study, Tomitch (2000a) investigated individual differences in WM capacity and the recall of predicted elements in the text. Her findings suggest that more proficient readers (higher spans) are able to recall elements predicted in the text, and also to notice distortions in terms of text organization. The results in her study reveal that individual differences can be explained by means of total capacity and processing efficiency. The former assumes that individuals vary due to the amount of activation they have available for supporting the two

functions - *storage and processing* - while the latter presumes that individuals vary in their processing efficiency of their mental processes. In other words, this researcher claims that higher span readers are more likely to easily perform complex cognitive tasks, since they do not consume all their mental processes available in their WM, thus leaving more capacity for the perceiving text organization, processing and storing of information from the text.

3 Conclusion

Regarding individual differences in WM capacity, there is a common agreement among researchers (DANEMAN; CARPENTER, 1980, 1983; DANEMAN; GREEN, 1986; JUST; CARPENTER, 1992; MIYAKE; CARPENTER, 1994; MIYAKE; FRIEDMAN, 1998; SHAH; MIYAKE, 1999; TOMITCH, 1996, 2000a) that individuals with larger WM capacities (higher spans or more efficient readers) perform better in complex cognitive tasks, such as in the reading skill, since they efficiently administrate the cognitive processes demanded by the task, whereas individuals with smaller WM capacity (lower spans or less efficient readers) seem to administrate these processes in a less efficient way.

In sum, several researchers' findings on individual differences in WM capacity and L2 reading comprehension certainly carry truth on them and corroborate with Tomitch's (1996) suggestion (although her study was carried out in L1) that individual differences in text organization, perception and working memory capacity may be a predictor of the readers' level of awareness of text structure. Thus, individual differences play a role in the way individuals use their knowledge to organize the flow of information processing in L2 reading comprehension.

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Notas:

[i] Bottom-up processing ensures that the listeners/readers will be sensitive to information that is novel or that does not fit their ongoing hypotheses about the content or structure of the text; top-down processing helps the listeners/readers to resolve ambiguities or to select between alternative possible interpretations of the incoming data (CARREL; EISTERHOLD, 1983, p. 557).

[ii] The theoretical term *retrieval* refers to the access of the information by recognition or recall, or implicitly by demonstrating that a relevant task is performed more efficiently as a result of prior experience (BADDELEY, 2004, p. 7).